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A Graduate Certificate Program in Nuclear Safeguards Technology

J. Neustrom, J. Gahl, W. Miller, M. Prelas, K. Trauth, T. Ghosh, G. Neumeyer
University of Missouri-Columbia, Nuclear Science and Engineering Institute

L. Fishbone, B. Siskind, S. Pepper
Brookhaven National Laboratory, Nonproliferation and National Security Department

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Brookhaven National Laboratory
P.O. Box 5000
Upton, NY 11973-5000
www.bnl.gov

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Abstract

While there are a number of university graduate-education programs that address non-proliferation and safeguards policy issues, there are none in the United States that train students in the specific technical aspects of nuclear safeguards. Formal education of this kind is necessary to sustain the flow of technically trained individuals to diverse programs in safeguards, nonproliferation, and national security. In response to this need, the University of Missouri-Columbia, with assistance from Brookhaven National Laboratory, is initiating a Graduate Certificate Program in Nuclear Safeguards Technology. Students seeking advanced degrees in a variety of technical areas will complete a required sequence of courses in order to receive the certification. Required course work covers topics such as Nuclear Material Control and Accountability (MC&A), Physical Protection (PP), nuclear measurements, and a variety of other relevant subjects. Laboratory-based instruction will be included which will utilize the University of Missouri Research Reactor (MURR). MURR is the largest university-based research reactor and has extensive laboratory resources including a Canberra Aquila MPC&A Operational Monitoring demonstration system.

Introduction

The increasing threat of the proliferation of nuclear materials has created a need for formal academic training in the nuclear safeguards field. Several universities offer a course on the policy aspects of nonproliferation, but no academic institution offers courses on the technical aspects of nuclear safeguards in the United States [1].

In order to meet the educational need, the University of Missouri-Columbia, with assistance from Brookhaven National Laboratory, is creating a Certificate Program in Nuclear Safeguards Technology (NST). The certificate will provide students with the skills needed to work in the technical area of nuclear Material Protection, Control and Accountability (MPC&A). The certificate course will create a foundation and broad range of knowledge on various aspects of MPC&A. Required course work covers topics such as nuclear material control and accountability (MC&A), Physical Protection (PP), nuclear measurements, and a variety of other relevant subjects.

The goals of the certificate program are:

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1) **To Train** technical personnel in the analysis, design, and implementation of safeguard systems,
2) **To Integrate** safeguards considerations into the design and operation of a nuclear facility,
3) **To Lead** the world in creating a unique and nationally-recognized certificate program that will encourage a better understanding of nuclear safeguards issues worldwide,
4) **To Increase** the level of awareness about safeguards in the technical community.

Students interested in advanced technical degrees will be able to earn the certificate by taking four courses at the University of Missouri-Columbia. The creation of the certificate will also require the creation of a new class in nuclear safeguards that will utilize a Canberra Aquila MPC&A Operational Monitoring demonstration system located at the Missouri University Research Reactor (MURR). In this paper, descriptions will be given of the four courses in the certificate program, with special attention given to the new Nuclear Safeguards Technology (NST) course that is the centerpiece of the program. In addition, a brief discussion will be given of the future of the certificate program.

Courses Needed for the MPC&A Certificate

For the successful completion of the MPC&A Certificate Program, students will need to complete four courses at the University of Missouri-Columbia. The courses will cover the various topics necessary for the understanding of nuclear safeguards. The courses needed for the certificate are discussed below. The main task associated with developing the certificate program is the creation of the NST course, the only one of the four required courses that is not yet being taught.

1) **Nonproliferation Issues for Weapons of Mass Destruction (WMD):** Topics discussed in this course include the various types of WMDs, the motivation for proliferation, the means of production of WMDs, and the effectiveness of nonproliferation efforts (prerequisite for the NST course).

2) **Nuclear Safeguards Technology:** This course will cover major aspects of the protection, control, and accountability of nuclear materials. In addition, techniques for the design of physical protection systems and current regulations governing the handling of nuclear materials will be covered.

3) **Radiation Safety:** Course content will include learning about various types of radiation and the detection of radiation. Furthermore, the current regulations regarding radiation safety along with the procedures for safe usage of radiation will be reviewed (prerequisite for the Radiation Detection course).

4) **Radiation Detection:** The focus of the course will be the application of radiation detection sensors and analyzers.

Nuclear Safeguards Technology Course

The foundation for the certificate program will be the Nuclear Safeguards Technology course. The goal of the course will be for the students to gain an awareness of the issues surrounding nuclear materials management and protection. By successfully completing the course, students will be able to characterize facilities (both in terms of physical and procedural concerns) and evaluate the effectiveness of nuclear materials management

strategies. To do so, the course will examine major aspects of the design and utilization of safeguards systems over 15 weeks as given in the outline (Figure 1).

1. **Introduction – 1 week**
   - **1.1.** Goals and objectives
   - **1.2.** Outline of topics
   - **1.3.** Important definitions
   - **1.4.** Philosophy
2. **Institutional and Technical Context – 2 weeks**
   - **2.1.** Domestic context
   - **2.2.** International context
   - **2.3.** Fuel cycle
   - **2.4.** Basic nuclear technology
3. **Physical Protection Systems – 3 weeks**
   - **3.1.** Structure and design of physical protection systems - Overview
   - **3.2.** Facility characterization - Targets
     - **3.2.1.** Types, locations, and quantities of nuclear materials
     - **3.2.2.** Fixed locations of nuclear materials – storage and use
     - **3.2.3.** Transfers and transport of nuclear materials – within facility and off-site [Flow of nuclear material at the facility]
   - **3.3.** Facility characterization – Access paths to targets
   - **3.4.** Threat definition
   - **3.5.** PP system components and structure
     - **3.5.1.** Intrusion sensors
     - **3.5.2.** Alarm assessment and display
     - **3.5.3.** Entry control
     - **3.5.4.** Delay
   - **3.6.** Response – protective forces
   - **3.7.** Analysis
     - **3.7.1.** Integration of components into a complete PP system
     - **3.7.2.** Software for analyzing PP system effectiveness
   - **3.8.** Risk assessment and vulnerability assessment
4. **Nuclear Material Accountability – 5 weeks**
   - **4.1.** Principles of nuclear material accounting
     - **4.1.1.** Generally Accepted Accounting Principles
     - **4.1.2.** Accounting systems and accountability values
     - **4.1.3.** Flow of nuclear material at the facility: accounting in nuclear material transactions
     - **4.1.4.** Nuclear material inventories
       - **4.1.4.1.** Book inventory and physical inventory
       - **4.1.4.2.** Verification and confirmation measurements
       - **4.1.4.3.** Nuclear material configurations – items, holdup, and bulk material
       - **4.1.4.4.** Inventory statistics – sampling plans
     - **4.1.5.** Material balance

- **4.1.6.** Documentation
- **4.2.** Nuclear material measurements
  - **4.2.1.** Measurement methods
    - **4.2.1.1.** DA - examples
    - **4.2.1.2.** NDA - examples
  - **4.2.2.** Measurement uncertainties
    - **4.2.2.1.** Sources of uncertainty
    - **4.2.2.2.** Precision and accuracy
    - **4.2.2.3.** Measurement control
    - **4.2.2.4.** Measurement statistics

5. **Nuclear Material Control – 1 week**
   - **5.1.** Access controls
   - **5.2.** Surveillance
   - **5.3.** Containment of nuclear materials
   - **5.4.** Detection/assessment of nuclear material removal
6. **Nuclear Material Infrastructure – 2 weeks**
   - **6.1.** Nuclear material regulations
   - **6.2.** Personnel security
   - **6.3.** Nuclear material data security
   - **6.4.** Nuclear material accountability at the national level
7. **Additional topics – 1 week**
   - **7.1.** Environmental sampling for nuclear safeguards
   - **7.2.** Remote sensing for nuclear safeguards
   - **7.3.** Literature analysis
   - **7.4.** Intelligence methods

Figure 1. Outline for the Safeguards Course

A unique aspect of the course is the hands-on training and practice of safeguards techniques that will take place in the laboratory section of the course. Laboratory exercises will involve equipment usage similar to what is utilized in the field. The physical protection section of the course will utilize a Canberra Aquila MPC&A Operational Monitoring Demonstration System located at MURR [2]. The demonstration system provides the unique opportunity to utilize safeguards equipment in the setting of a nuclear facility. Various cameras (see example in Figure 2), radiation sensors, and door sensors comprise the system. In addition, several model facilities will be used for risk analysis and facility characterization exercises. All lab activities will accurately recreate situations encountered in the current safeguards operating environment.

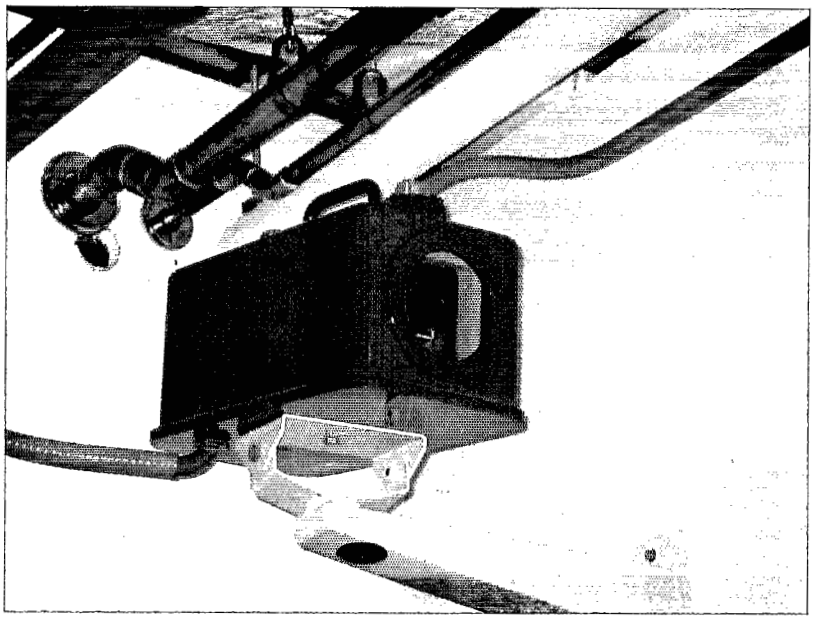

Figure 2. Camera for Canberra Aquila MPC&A Operational Monitoring Demonstration System

Specific exercises on physical protection systems will include the risk analysis of threats to a model facility. Students will have to understand the various methods of identifying threats and characterizing facilities to complete the laboratory assignment. In addition, students will learn how to utilize demonstration physical protection sensors at MURR to detect a potential adversary. In the area of MC&A, laboratory exercises will include destructive and nondestructive measurement of nuclear materials. Furthermore, exercises will be included concerning the control and accountability of nuclear materials and how to address discrepancies in the quantities of materials shipped and subsequently received. All of the exercises will give students experience in issues that are prevalent in the safeguards field of work.

Along with laboratory work and instructional exercises, the course will also consist of lectures three times a week and weekly quizzes. As a measure of a student's grasp of the concepts, two tests will be given during the semester. Information for the course will come from various handouts and two textbooks [3,4].

The Future

Although three of the four courses exist for the certificate program, the NST course is currently being developed at the University and the certificate program will be operational by the Fall 2005 semester. The course will be offered for either graduate or undergraduate credit. In the future, more courses may be added to the certificate curriculum, including a second nuclear safeguards course. Students will also be allowed to take several elective classes that are related to the certificate program, including topics such as remote sensing; data mining; nuclear, biological, and chemical (NBC) sensors; and counter-terrorism.

Individuals working for various entities such as the Department of Energy, the Department of Defense, commercial power plants, nuclear medicine facilities and other private concerns would be expected to benefit from the certificate program. The four-course certificate program will expand the awareness and knowledge of technical issues in nuclear safeguards. In addition, the program will also encourage research in nuclear safeguards-related technologies and create a better safeguards culture among technical personnel. The intent of the safeguards certificate program is to make the world safer through the promotion and enhancement of Nuclear Material Protection, Control and Accountability.

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